Thomson

# A NEW WOOL-TEST FOR THE DETECTION OF COLOR-BLINDNESS



BY

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THE new test herewith presented is based upon and is a simplification of and improvement on the "color-stick," an arrangement of wools adopted by the Pennsylvania Railroad Company in 1880, and described in their instructions for the examination of their employés, and further in THE MEDICAL NEWS of January 14, 1882; in the *Diseases of the Eye*, by Nettleship; and in the *Popular Science Monthly* for February, 1885, under the title of "A Practical Examination of Railway Employés as to Color-blindness, Acuteness of Vision, and Hearing."

The entire system has been continued on the Pennsylvania Railroad unchanged, giving full satisfaction, and is used as a barrier before every new employé to protect the road from the admission of dangerous men. It has been adopted by the Philadelphia and Reading Railroad Company and by others, as is shown by the replies received in response to a circular recently sent to a hundred of the most important railroad corporations of this country, controlling 129,970 miles, asking if exami-

nations were made as to color-blindness. Thus, it was found that

| | |
|---|---|
| Those using Dr. Thomson's test controlled | 38,786 miles. |
| Those using other methods controlled | 15,679 " |
| Those making no test controlled | 29,428 " |
| Those making no reply controlled | 46,077 " |

Sixteen other roads having control of 12,947 miles have also adopted my color-stick, thus making a grand total of 51,733 miles protected by this test out of 142,917 covered by the investigation. The total number of roads included is 116; of these 40 use my color-stick; 11 use other color-tests, mainly Holmgren's; 31 use none; 34 have made no response. The entire system has also been in use on the Midland and on the London and South-western in England.

The Pennsylvania Railroad system has accomplished much good, but there is yet much to be done to bring all the roads in the country under the protection of some efficient method of testing, to secure both the roads and the public against loss of life and property from these well-known defects of their employés. The total mileage of the country is 175,233 and there are 1,000,000 employés.

The protection of over 50,000 miles of track by one system is an efficient answer to the charge from England, where the total trackage is but 19,288 miles, that nothing had been done in the United States beyond the passing of a law in the State of Alabama on this subject.

As the result of much experience, and after a recent study of the entire subject, I would suggest some improvements that will enable a new test to be

used in connection with the color-stick or as a substitute for it. The color-skeins of this new arrangement have been most carefully selected, and a standard set will be kept, so that renewals may be made of the entire set or of those skeins that may become faded, soiled, or lost. The new set consists of a large green and a large rose test-skein, and forty small skeins, each marked with a bangle having a concealed number, extending from 1 to 40, placed in a double box, so arranged as to keep the two series apart and to permit each to be exposed upon a table in a confused mass. The stick is dispensed with, as giving too fixed an arrangement to the skeins and not enough *confusion*, although the skeins could be readily removed from their hooks and changed in position for this purpose.

The large green skein being placed near by, the small skeins from one to twenty are exposed in good daylight, and the employé under examination is directed to select ten shades of the same color of the test-skein. One with normal vision will choose promptly and with ease the ten greens with odd numbers on the bangles. A color-blind person will hesitate, and his selections will contain some even numbers, and the confusion-colors will be shades of brown, etc., containing some red, or shades of gray, and will indicate the color-defect. These figures are to be recorded on a blank, and the twenty skeins are to be removed. The large rose skein is then used and the examination repeated in like manner with skeins numbered from 21 to 40, and the result recorded. The confusion-skeins, which have even numbers, are blue, green, and gray. From the selections

made by the man found color-defective by the green-test, we are able to decide the character of his color-blindness. Those selecting blues are red-blind; those taking greens and grays are green-blind, according to the nomenclature of Holmgren. There are ten roses and ten confusion-colors in the second series.

The red test-skein of the stick, with its confusion-colors, is omitted entirely, and the test is made to conform more strictly with Holmgren's method, while the examiner is also provided with forty questions of decisive clearness. Greater scientific accuracy is obtained by this method, and with the careful selection of these confusion-colors I now regard this system as an improvement upon the stick, and as a safer and more simple method to be used by a non-professional examiner. The blank will also give to the division superintendent or to any supervising surgical expert a more simple report of the examination. The yarns are to be kept from the light in the double box, one side of which is colored green and the other rose, to aid the examiner in keeping the series separate and to save time. The test will be a valuable addition to those to be used by surgical experts.

In order to show how the Pennsylvania Railroad Company keeps its records of these examinations we submit the following fac-simile of an actual blank:

WEST JERSEY RAILROAD COMPANY.

CAMDEN, January 19, 1883.

Examination of sight and hearing of James A. Morris, aged twenty-two, employed as locomotive fireman, applicant for

.....

| ACUTENESS OF VISION. | | RANGE OF VISION. | | |
|---|---|---|---|---|
| The number of the series seen at twenty feet distant. | | Least number of inches at which type D—0.5 in test-type pamphlet can be read. | Right eye, 4½ inches | Left eye, 4½ inches |
| Right eye | 20–30 | | | |
| Left eye | 20–20 | | | |
| | | FIELD OF VISION. | | |
| | | Good or defective . . . | Good. | |

*Color-sense.*

| Test-skein submitted. | Name given. | Numbers selected to match. |
|---|---|---|
| A—Green | Green | 3, 26, 24, 7, 11, 22, 15, 5, 1, 17, 28, 9, 19, 30, 13 |
| B—Rose | Red | 37, 33, 29, 12, 39, 31, 21, 35, 25, 27, 23 |
| C—Red | Red | 37, 33, 31, 35, 23 |

| Second Color-test. | | | Third Color-test. | | |
|---|---|---|---|---|---|
| Number shown. | Name given. | Numbers selected. | Flag shown. | Name and use given. | Numbers selected. |
| 24 | Green. | 26, 22. | Soiled White. | Safety, White. | 2, 4, 6. |
| 39 | Yellow red. | Could find no match. | Soiled Green. | Caution, Green. | 36, 38. |
| 30 | Blue. | 26. | Soiled Red. | Danger, Red. | 37, 33, 31. |

*Selection prompt or hesitating:*
Prompt.

*

*Hearing.*

| Right Ear. | | Left Ear. | |
|---|---|---|---|
| Watch. | Conversation. | Watch. | Conversation. |
| 8 feet. | 20 feet. | 8 feet. | 20 feet. |

*Remarks:*

Escaping steam prevented watch-test.

J. J. BURLEIGH, *Examiner.*

Acuteness, right eye defective. Range, good. Field, good. Color-sense, defective. Hearing, see Remarks.

JOS. CRAWFORD, *Superintendent.*

NOTE.—Those approved, marked "Appd."
Those not approved, marked "Not Appd."

It may be of service to present to the surgical experts in charge of the examinations of the various railroads the means that I have adopted for my own guidance in giving my final decisions. From the numerous methods described by scientific authorities I have selected ten that are practical, simple, and especially fitted for the detection of color-defects in employés of railroads. A book of record should be kept in which each case, with the results of the testing, should be entered. The Pennsylvania Railroad system provides that the preliminary examination should be made under the direction of the division-superintendent by non-professional examiners, but it is to be under the supervision of one professional competent surgeon, who is known as the surgical expert, who becomes responsible for the qualities of the tests, and who gives the final decision in all

cases referred to him. Thus the men are protected from the errors of lay-examiners, and do not lose their places until pronounced defective by professional authority. With ordinary care no color-blind man should escape detection by the lay-examiner, but men really fit for the service might be unfairly treated.

When referred to the expert the man found color-blind will present himself with the blank of his examination, and the surgical expert will then corroborate this by the following means:

1. The stick or the new test-skeins; or both.

2. Holmgren's set of one hundred of fifty various-colored skeins will be used and the proportion of mistakes recorded.

3. Browning's pocket spectroscope will then be used, and the man be directed to describe the colors he sees when looking through the instrument. If color-blind he will say that he sees but two colors, yellow and blue, with a gray or a neutral band between then.

4. The color-tables of Stilling will then be used; these are so arranged that on a colored background letters and figures are printed in the confusion-colors of this background so as to be indistinguishable by the color-blind.

It now becomes requisite to test the central vision, and to determine the power to perceive the signal-colors that are used by night.

5. A piece of dark cobalt-blue glass should be used in the trial-frame over each eye separately, and the man be directed to look at the flame of a candle or other small light, from a distance of twenty

feet. An eye normal in refraction and color-sense sees the light, colored rose or pink, surrounded by a blue halo. To a hypermetrope there may be a blue light, with a ruby-colored ring or halo; but two colors will always be seen, whilst the color-blind man sees but one color, blue, or a light spot with a blue halo.

6. Donders' instrument has a standard candle in a dark cylinder, with a wooden disc, and pieces of red, green, blue, and white glass so arranged as to be rotated in turn in front of the flame. Here also there is a metallic slide, with perforations ranging from one to twenty millimeters in diameter. The man is placed five meters away, and while the colors of the light are changed by rotating the disc he is challenged to designate the colors of the transmitted light. The normal eye recognizes them through the 1 mm. opening at 5 m.; or, better still, the candle is so placed that the examiner with normal color-sense just perceives the color through the 1 mm. opening at 5 m. The color-blind individual may fail through a series of openings until the 20 mm. one is presented. He may still call white green, and red green. If so, he is asked the significance of the green, and answers "caution." He is then requested to approach the light slowly, and as he does this he may perhaps at one meter or one-third of a meter, by its intensity or size, recognize and call it red. Using the same ratio for his color-blindness as we employ for his acuteness of vision, we can reason thus: Full color-sense enables one to see the lights promptly at 5 meters through the 1 mm. opening; if the man sees them only after the

apertures have been increased, his color-sense must be defective. Thus, if an opening of 20 mm. is needed, the color sense $\frac{1}{20}$; should the man fail with the 20 mm. opening at 5 m. he is told to approach it, and if he sees it at 1 m. he has $\frac{1}{100}$ of color-sense, and if at $\frac{1}{3}$ of m., or 1 foot, he has only $\frac{1}{300}$ of the normal power. The mere diminution of white light, by interposing pieces of London smoke, may induce the color-blind to pronounce it in turn white, green, and finally red.

7. A tin lantern, with a switchlight condenser having a four-inch opening arranged so as to admit of placing pieces of white (ground), green, red, blue, and London-smoke glass before it, is now employed. This could also be made to take the place of Donders' instrument, if covered with a front, and with a sliding-piece with small perforations. A man failing to recognize the light from a four-inch aperture leaves no possible room for doubt, and this fixture is useful in convincing the friends of the man, and any railroad officers who may desire a rude test. The light is in diameter 100 mm., and should be seen at 500 meters.

8. The instrument of Mr. Carter, of London, is then made use of. This is to guard the surgical expert against a hasty opinion, and is to act as a check upon all wool-tests. It is based upon the sensibility of the retina and its power to recognize form and color in various intensities of light. The surgeon and the man examined regard the tests simultaneously while the quantity of light is varied; thus, possible errors with other tests, especially Holmgren's, can be avoided.

9. In Dr. Chibret's instrument, by means of polarized light various colors may be produced at will. The color-blind betray themselves by placing the instrument so that two dissimilar discs of light appear to them alike.

10. Finally, an assortment of flags that have been in actual use, ten of each color, white, green, blue, and red are used as a test. These are thrown down in a confused mass on the floor, and the man is directed to properly assort them. Astounding mistakes are often made; as, for example, when a man is directed to take a red flag and use it to protect the rear of a train, he may select a green one.

A profound understanding of this curious defect of color-perception must be acquired to enable the surgical expert to make the best use of these various methods, and whilst they are sufficient they are decisive and require but little time. Perhaps the transcript of one case from my record-book may illustrate these brief descriptions:

J. H., employed by the Pennsylvania Railroad Co., forty three years old; found defective, and referred for final opinion.

Color-stick: With green, selects Nos. 1, 2, 3, 4, 6, 7, 11, 13, 15, 17; with rose, selects Nos. 22, 25, 21, 27, 28; with red, selects Nos. 31, 32, 33, 34, 37.

Holmgren: Green, selects 2 greens and 21 confusions; rose, selects 5 greens, with 13 confusions; red, selects 8 greens, with 9 confusions, 2 greens.

Donders: Fails at 5 m. on all apertures; fails at 1 m. on all apertures; ⅓ m. on all apertures.

Calls, with 20 mm. opening, green red; red green, and white, light-red.

He made more mistakes than successes, with gray (London-smoke glass) over white; called it red and green, as light was increased or diminished, and finally declared that he had never seen such lights on a railroad.

Failed with switchlight, 4 inches in diameter, at 5 m. and at 1 m., and manifested a color-blindness or defect greater than $\frac{1}{500}$, as he failed to see at 1 m. what a normal eye would recognize infallibly at 500 meters.

Cobalt-glass: Sees white light with blue halo; no red or rose.

Flags: At 1 m. calls dirty-white green; fails to distinguish red from green. He was then told to select from a pile of flags the danger-signal, or red one, and to hurry back and protect his train; with his own hands and deliberately he chose six—three red, two green, and one blue—stating that "they would all stop trains."

Stilling's tables: Fails in all but VII, which should be recognized by a color-blind.

Pronounced color-blind and unfit for any duty in which he would govern his actions with color-signals.

I will conclude by urging the need for reëxaminations at stated periods, and in individual cases when a man has been injured, or has recovered from a serious illness, or when he uses tobacco or alcohol to excess.

The test here described can be obtained of Queen & Co., of Philadelphia.